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A SMALL AND LIGHT THYRATRON GRID DRIVER*

Randall I. Ross
Lawrence Livermore National Laboratory
P. O. Box 808
Livermore, CA. 94550

Introduction

The Laser Isotope Separation Program at Lawrence Livermore National Laboratory is aggressively developing Copper Vapor Laser's (CVL's) for use as dye laser exciters. These CVL's require high voltage (>10 kilovolts), high peak current (>1200 amps), and operate at high repetition rates (up to 12 kilohertz) with fast current risetimes (<50 nanoseconds). Thyratrons are typically used to provide the required pulsed energy to the lasers. Three to five inch ceramic thyratrons, such as EG&Gs' HY-1802 or ITTs' F-117, are now used depending upon the application. To trigger these thyratrons a low jitter, reliable and compact pulser was developed by the laboratory.

Originally line type and hard tube pulsers were employed. Both in-house and commercial units were used, but these suffered various disadvantages (cost, size, reliability, insufficient output drive, etc.). The newest design, that is reported here, is based on an in-house designed line type pulser, but makes use of a high-voltage switching power supply to provide a reliable, compact, fault-tolerant unit. This pulser is referred to as the thyratron grid driver, and is now in general use in our laboratories. This unit is shown in Figures 1 & 2. A circuit diagram of the new pulser is shown in Figure 3.

The 200 watt switching power supply was specially designed under contract by CETA Corporation. Operating at a switching frequency of 40 kilohertz, this power supply will ramp charge the capacitors in the Pulse Forming Newtork (PFN) in less than 77 microseconds. This allows the repetition rate of the pulser to be continuously variable from 0-13 kHz with no variation of output waveform, as would be the case with a simple resonantly charged line type pulser. In addition the supply is short circuit proof and incorporates a fast regulator circuit (<10 μs response).

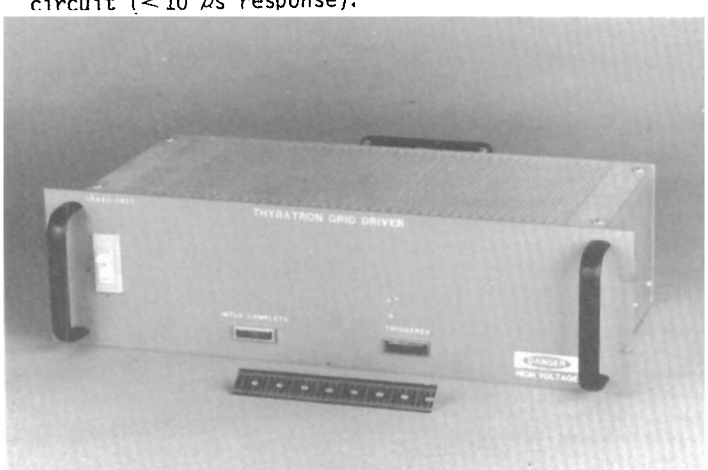

Figure 1

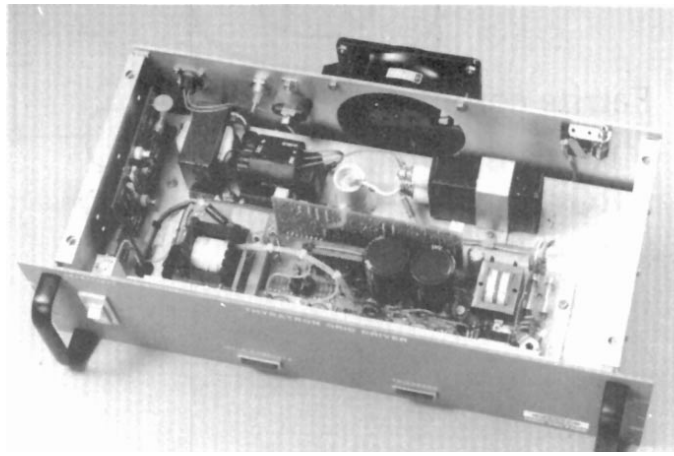

Figure 2

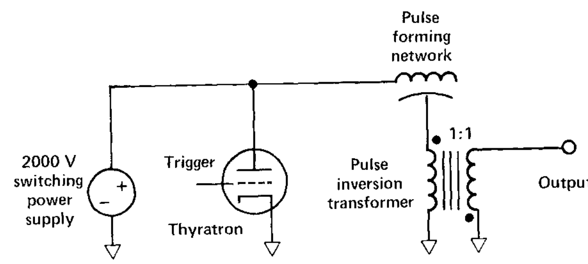

Figure 3

The short circuit current of the supply has a waveform that consists of pulses of current at the power supplies switching frequency which occur at a longer interval than the thyratrons recovery time. This means that during pulser operation, the switching power supply can not keep the pulser thyratron in conduction after the PFN has been discharged. This eliminates latch-up problems by providing in effect a command charge circuit.

A 3 kilovolt (kV), 330 nanoseconds pulse width, 50 ohm PFN was custom made in a small package by Plastic Capacitor, Inc. The pulser thyratron is a EG&G HY-2 which is normally used for radar applications. Figure 4 shows a typical 50 ohm pulse output into a matched thyratron load.

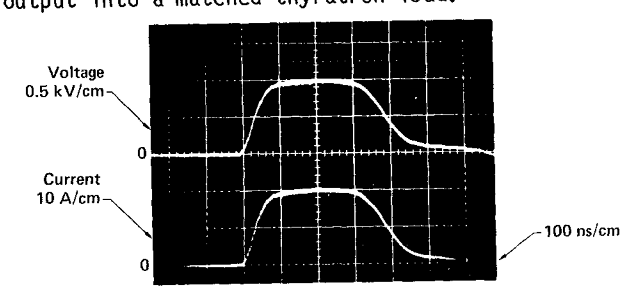

Figure 4

*This work performed under the auspices of the Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

The physical dimensions of the thyratron grid driver is 5 1/4" (13.3 cm) tall, 8" (20.3 cm) deep, and 19" (48.3 cm) wide. It weighs 15 lbs. (6.8 kg), uses 2 amps of 120 VAC, and runs about $3K per unit.

This circuit has successfully operated continuously for over two thousand (>2000) hours in actual high power thyratron circuits without failure. The testing is still continuing. The electrical characteristics of this pulser are shown in Table I.

TABLE I

Pulse width	300 ns
Pulse risetime (10-90%)	50 ns
Pulse voltage (open circuit)	2 kilovolts
Pulse voltage (50 Ω)	1 kilovolt
Output impedance	50 ohms
Maximum repetition rate	12 kHz
Pulse jitter	<1 ns

Out put short circuit and overvoltage protection.

Other pulse formats can be generated within this circuit by changing the PFN design, as long as the maximum average power, peak charging current and maximum charging voltage are not exceeded. The average power delivered to the load is simply given by:

$$P=1/2\ CV^2f \leqq 200 \text{ watts}$$

where P is the average power of the power supply, C is the capacitance of the PFN, V is the matched output pulse voltage, and f is the repetition rate.

Futher development on this unit is continuing. Stacked Field Effect Transitors (FET) are being investigated to replace the small thyratron. Also the packaging of this pulser and an equally small heater/resevoir and grid bias power supply is being considered to produce a single chassis complete thyratron service unit. Clearly a careful job of packaging has improved the usefulness of these thyratron triggers.